TAXONOMY, SOCIOBIOLOGY, NUTRITIONAL AND NUTRACEUTICAL POTENTIAL OF TERMITOPHILOUS AND LEPIOTOID MUSHROOMS FROM NORTH WEST INDIA

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ABSTRACT

The present paper deals with biology and the evaluation of nutritional and nutraceutical potential of wild edible lepiotoid and termitophilous mushrooms from North West India. The studies reveal that presence of appreciable amount of most of the essential nutrients. Out of the total wild mushrooms analysed, *Termitomyces medius* possessed maximum (46.2%) amount of protein followed by *T. badius* (44%) whereas *T. striatus* possessed the least amount(12.95%) on dry weight basis. Maximum percentage of fat was in *Macrolepiota procera* (3.4%) followed by *T. mammiformis* (3.3%). All other mushrooms had considerably low percentage of crude fat per 100 g of dry sample. The crude fibre content was highest in *T. mammiformis* (8% of dry weight) while *T. badius* and *M. rhacodes* possessed minimum percentage of crude fibre (2.5%). The carbohydrate content was highest in *T. striatus* was evaluated to contain (60.27%) followed by *T. mammiformis* (47.65%) while lowest carbohydrate content was in *T. microcarpus* (33.5%) and *T. medius* (33.3%). The overall energy value was maximum in *M. rhacodes* (364.7 kJ) as compared to the species of *Termitomyces* and *Macrolepiota*, evaluated. Amongst the minerals, Fe content was maximum in *T. mammiformis* (673 mg/100 g dry weight) followed by *T. radicatus* (482 mg/100 g) and minimum in *T. striatus* (82 mg/100 g). In addition *Termitomyces* species are quite rich in Mg. *T. medius* (330 mg/100 g) had maximum amount of Mg followed by *T. heimii* (287 mg) and minimum in *T. microcarpus* (6 mg/100 g). Mn (13mg/100 g) and Ca (204mg/100 g) content was highest in *T. medius* and minimum amount of Manganese (1 mg/100 g) was recorded in *M. dolichaula* and *T. microcarpus* (6 mg), respectively. Cu was maximum in *T. striatus* (11 mg/100 g) followed by *T. radicatus* (9 mg/100 g) and *T. badius* (7 mg /100g). As compared minimum quantity of this element was in *T. mammiformis* (4 mg). Zn was maximum (94.3 mg/100g) in *M. rhacodes* followed by *T. microcarpus* (79.5 mg/100 g), whereas minimum quantity of Zn was recorded in *T. radicatus* (35.9 mg/100 g). The nutraceutically important nutrient Se was maximum in *T. microcarpus* (123.2 mg/100g) followed by *T. heimii* (113.10mg/100 g) whereas minimum amount of this element was recorded in *T. striatus* (46.5 mg/100g). The dry mushroom samples were also evaluated for the presence of heavy metals. Traces of some heavy metals, viz. Hg, As and Cd were detected in *T. radicatus, T. medius, T. badius, T. microcarpus* and *M. rhacodes* while Cr, Ag, and Pb were found to be absent in these mushrooms. Phenolic content in *T. microcarpus* (25.85 mg) was maximum, followed by *T. mammiformis* (22.5 mg) and minimum in *M. dolichaula* (5.9 mg). Flavonoids were found in small amount ranging between 1.36 mg/g in *T. microcarpus* and 2.02 mg/g in *M. rhacodes*. The β-carotene content was found in very low amount in different species ranging from 1.1 μg/g in *T. heimii* to 1.5 μg/g in *T. badius.* Lycopene was found to be least in these species ranging from 1.03 μg/g in *T. heimii* to 1.27 μg/g in *T. striatus.* Alkaloids were found in very small concentration ranging between 0.046 mg/g in *T. radicatus* and *T. heimii* and 0.103 mg/g in *M. dolichaula.* Substantially low amount of phenolic content, carotenoids, alkaloids and flavonoids detected in these mushrooms account for their antioxidant property. Maximum content of vitamin A (retinol) in the analysed mushrooms was observed in *Lepiota humei* (0.17 mg/ 100 g) followed by *T. heimii* (0.12 mg/ 100 g) and minimum in *M. dolichaula* (0.075 mg/100 g). As compared thiamine (Vitamin B1) content ranged from 0.75 mg/100 g in *M. rhacodes*to 0.21 mg/100 g in *T. heimii* and the riboflavin (Vitamin B2) content was maximum in *T. heimii* (0.25 mg/100 g) and minimum in *M. rhacodes* (0.13 mg/100 g). Vitamin C (Ascorbic acid) was maximum in *T. reticulatus* (1.45 mg/100 g) and minimum in *L. humei* (0.18 mg/100 g). The nutritional and nutraceutical constituents in these mushrooms are comparable to commonly cultivated mushrooms. Their culinary credentials also compares well with the commonly consumed vegetables. These mushrooms need to be explored further with a view to conserve them and domesticate them so that these can be fruitfully used for human welfare.

Keywords: taxonomy, sociobiology, nutraceutical potential, termitophilous mushrooms, lepiotoid mushrooms

INTRODUCTION

The lepiotoid and termitophilous mushrooms are practically important for their edibility and nutritional profile, medicinal utility and unique flavour man has been hunting for wild mushrooms since times immemorial [1, 2]. Their fresh fruit bodies are sold in the markets of Thailand, along road sides in Old World Tropics [3, 4] and many parts of India [5-8].

Furthermore these mushrooms are also reported to have high medicinal attributes. These properties make them important from the human health point of view. In the trade and manufacture of valuable compounds from these mushrooms, scientists from African countries and South-East Asian countries like South Africa, Thialand, Old Tropics, Tanzania, China and North America are doing lot of work [9-15].

In view of above investigations for evaluation of nutritional and nutraceutical prospects of these species of lepiotoid and termitophilous mushrooms collected from different localities of North part of India was initiated. The results of which are presented in this manuscript.

MATERIALS AND METHODS

Fully mature samples of all wild edible lepiotoid and termitophilous mushrooms were collected from North West India during monsoon season, and ethnomycological information with respect to each one of them was collected using questionnaires, personal observations, and inter-views with old and experienced persons and local informants. Among the interviewees, about 30%– 40% were aware of the ethnomycological uses, out of which a majority (80%) were the elders (above 60 years of age). The specimens were dried at 45 °C for preserva-tion. The dried samples were used for nutritional and nutraceutical studies. The analysis of each collected sample for nutritional attributes was carried out following standard protocols.

Standard techniques of analysis as published by AOAC from time to time for determining the proximate composition of mushrooms (carbohydrates, crude fat, proteins, fibers, ash, moisture content, minerals, heavy metals and vitamins) were employed.

The per cent carbohydrate content present in the mushroom samples was estimated by substracting the total components excepting carbohydrates from 100 g of mushroom samples as per the following relation after Crisan and Sands [16].

Carbohydrate % = 100 - (Protein + Fat + Fiber + Ash Content + Moisture Content)

So as to determine the fat content in the wild samples of edible mushrooms, solvent extraction method as given by AOAC [17] was followed. The per cent crude fat in the mushroom was determined by employing the following relation.

$$\text{Crude Fat}\,\% = \frac{\text{Weight of Ether Soluble Material}}{\text{Weight of the Sample}} \times 100$$

For the calculation of crude protein content in the form of per cent nitrogen, following relation as given by AOAC [18] was followed.

$$\text{Nitrogen}\,\% = \frac{\text{Titrate Volume} \times 0.00014 \times \text{Volume made}}{\text{Aliquot taken} \times \text{Weight of the Sample}} \times 100$$

The fiber estimation was done according to the method given by Maynard [19] and calculated as

$$\text{Crude Fiber}\,\% = \frac{\text{Loss of Weight on Ignition}}{\text{Weight of the Sample}} \times 100$$

The ash content was determined as residue after incineration by following the protocol given by AOAC [20] and calculated by using the following the formulation

$$\text{Crude Ash \%} = \frac{\text{Weight on Ash (g)}}{\text{Weight of the Sample}} \times 100$$

The moisture content estimation was done according to the method given in AOAC [20] and calculated as

$$\text{Moisture Content \%} = \frac{\text{Loss of Weight (g)}}{\text{Weight of the Sample}} \times 100$$

Quantitative estimation of minerals and heavy metals was done by the method of Jackson [21]. Vitamins were estimated by the methods given in Indian pharmacopeia [22]. In the extraction procedure for neutraceutical evaluation the fruiting bodies were air-dried in a Lyophilizer (Ly-Christ Alpha1-2) and powdered before analysis. The dried samples (5 g) were extracted by stirring with 100 ml of methanol at 25 ± ºC at 150 rpm for 24 hr. and filtered through Whatman No. 4 paper. The residue was then extracted with two additional 100 ml portions of methanol, as described earlier. The combined methanolic extracts was evaporated at 40 ± ºC to dryness and re-dissolved in methanol at a concentration of 50 mg/ml, and stored at 4 ±ºC for further use for extraction of different nutraceutical components.

Phenolics (Singleton and Rossi [23]): Phenolics were determined by a Folin–Ciocalteu assay. The extract solution (1 ml) was mixed with Folin–Ciocalteu reagent (5 ml, previously diluted with water 1:10, v/v) and sodium carbonate (75 g/l, 4 ml). The tubes were vortex mixed for 15 seconds and allowed to stand for 30 minutes at 40ºC for colour development. Absorbance was then measured at 765 nm. Gallic acid was used to obtain the standard curve (0.0094 – 0.15 mg/ml), and the results were expressed as mg of gallic acid equivalents (GAE) per g of extract.

Flavonoids (Yoo *et al*. [24]): For flavonoids quantification, the extract sample concentrated at 2.5 mg/ml (0.5 ml) was mixed with distilled water (2 ml) and $NaNO_2$ solution (5%, 0.15 ml). After 6 min, $AlCl_3$ solution (10%, 0.15 ml) was added and allowed to stand further for 6 minutes. NaOH solution (4%, 2 ml) was added to the mixture, followed by distilled water until a final volume of 5 ml was obtained. The mixture was properly mixed and allowed to stand for 15 minutes. The intensity of pink colour was measured at 510 nm. (+). Catechin was used to make the standard curve (0.015 – 1.0 m M) and the results were expressed as mg of (+)-chatequin equivalents (CE) per g of extract.

Carotenoids (Barros *et al.* [25]): For β-carotene and lycopene determination, the dried methanolic extract (100 mg) was vigorously shaken with 10 ml of acetone–hexane mixture (4:6) for 1 minute and filtered through Whatman No. 4 filter paper. The absorbance of the filtrate was measured at 453, 505 and 663 nm. The amount of β-carotene and Lycopene was calculated according to the following equations: For β-carotene (mg/ 100 ml) = $0.216 \times A_{663} - 0.304 \times A_{505} + 0.452 \times A_{453}$ and lycopene (mg/100 ml) = $-0.0458\ A_{663} + 0.372\ A_{505} - 0.0806\ A_{453}$. The results were expressed as ìg of carotenoid/g of extract.

Alkaloids (Maxwell *et al*. [26]): The alkaloids were extracted from 5 g of each of the dried powdered mushroom samples using 100 ml of 10 % acetic acid, which was left to stand for 4 hrs. The extract was filtered to remove cellular debris and then concentrated to a quarter of the original volume. To this concentrate, 1 % Ammonium solution was added drop-wise until the formation of precipitate. The alkaloids thus obtained were dried to a constant weight at 65 ºC in an oven. The percentage of alkaloids was calculated by using formula.

$$\text{Percentage alkaloids \%:} = \frac{\text{Weight of residue}}{\text{Weight of thesample}} \times 100$$

Three samples of each species wereanalyzed for statistical analysis and all the assays were carried out in triplicate. The results are expressed as mean val-ues and standard deviation (SD). The results were analyzed using one-way analysis of variance (ANOVA).

RESULTS

A. Nutritional Compositions

The results of the studies carried out on the 7 species of *Termitomyces* viz., *T. badius, T. heimii, T. mammiformis, T. medius, T. microcarpus, T. radicatus, T. striatus, T. reticulatus* and 3 species of *Macrolepiota* viz., *M. dolichaula, M. procera, M. rhacodes* on a dry weight basis are presented in Table 1.

Proteins: The results show that maximum protein content was found in *T. medius* (46.2%), followed by *T. badius* (44%), while *T. striatus* (12.95%) contained the lowest amount of protein.

Table 1. Proximatecomposition of wild ediblemushroomsfrom North India

S.No.	Name of Species	Carbohydrate (%)	Crude Fat (%)	Proteins (%)	Fibers (%)	Ash (%)	Moisture (%)
1	*Macrolepiota dolichaula*	56.2 ± 0.10	3.2 ± 0.20	19.95 ± 1.35	4.85 ± 0.18	7.3 ± 0.15	8.5 ± 1.47
2	*M. procera*	60.82 ± 0.11	3.4 ± 0.08	19.95 ± 1.06	5.1 ± 0.22	1.93 ± 0.06	8.8 ± 0.62
3	*M. rhacodes*	68.19 ± 0.17	2.9 ± 0.11	16.45 ± 0.54	2.5 ± 0.01	2.16 ± 0.14	7.8 ± 0.62
4	*Termitomyce sbadius*	39.0 ± 0.17	2.2 ± 0.10	44.00 ± 0.10	2.5 ± 0.01	6.6 ± 0.03	5.7 ± 0.22
5	*T. heimii*	36.2 ± 0.72	1.65 ± 0.19	40.95 ± 0.84	5.0 ± 0.11	8.6 ± 0.05	7.6 ± 0.23
6	*T. mammiformis*	47.65 ± 0.02	3.3 ± 0.17	23.45 ± 0.04	8.0 ± 0.26	9.9 ± 0.09	7.7 ± 0.06
7	*T. medius*	33.3 ± 0.37	2.0 ± 0.05	46.2 ± 0.02	7.5 ± 0.04	5.0 ± 0.20	6.0 ± 0.17
8	*T. microcarpous*	33.55 ± 0.11	2.5 ± 0.01	37.45 ± 0.45	5.0 ± 0.11	15.6 ± 0.06	5.9 ± 0.24
9	*T. radicatus*	41.07 ± 0.03	1.8 ± 0.12	40.00 ± 0.20	4.8 ± 0.04	6.3 ± 0.08	6.03± 0.02
10	*T. striatus*	60.27 ± 0.20	3.25 ± 0.06	12.95 ± 0.05	4.1 ± 0.15	12.13 ± 0.33	7.3 ± 0.18

Carbohydrate: Carbohydrate percentage was found to be maximum in *M. rhacodes* (68.19%), *M. procera* (60.82%), while *T. medius* (33.3%) contained the lowest amount of carbohydrate.

Crude Fat: Maximum amount of crude fats was evaluated in *M. procera* (3.4%). The percentage was comparable in *M. dolichaula* (3.2%), followed by *T. mammiformis* (3.3%) and *T. striatus* (3.25%) and least in *T. heimii* (1.65%)

Fibers: The fiber percentage on dry weight basis in termitophilous mushrooms range from 2.5% - 8% which is substantially high in comparison to species of *Macrolepiota*, where *M. procera* has been evaluated to contain 5.1% fibers in comparison to 4.85% in *M. dolichaula*and 2.5% in *M. rhacodes.*

Ash: Termitophilous mushrooms contained substantially high percentage of ash content which ranged from 5.0% in *T. medius*to 15.6% in *T. microcarpus* as compared to lepiotoid mushrooms where *M. dolichaula* contained maximum (7.3%) and minimum in *M. procera* (1.93%).

Moisture: During the present investigation the moisture percentage in air-dried samples ranged between 5.7% (*T. badius*) to 7.7% (*T. mammiformis*) in termitophilous mushrooms in comparison to 8.8% in *M. procera*.

Minerals: Out of 10 wild samples examined for estimation (Table 2), maximum amount of Fe (673 mg) was recorded in *T. mammiformis* followed by *T. radicatus* (482 mg) while *T. striatus* (82 mg) contained lowest amount of Fe. Other seven species also possessed significant levels of the mineral element. Mg was maximum in *T. medius* (330 mg) followed

by *T. heimii* (287 mg) where as minimum quantity of Mg (6 mg) was recorded in *T. microcarpus.* Maximum amount of Ca (204 mg) was recorded in *T. medius* followed by *T. radicatus* (109 mg) whereas minimum quantity was documented in *M. dolichaula* (5 mg). Cu was maximum in *T. striatus*(11 mg) followed by *T. radicatus* (9 mg/100 gm dry wt.) and *T. badius* (7 mg) where as minimum quantity of this element was detected in *T. mammiformis* (4 mg). Mn was maximum in *T. medius* (13 mg) followed by *T. radicatus* (10 mg). Minimum amount of Mn (1 mg) was recorded in *M. dolichaula.* Zn was maximum (0.09 mg) in *M. rhacodes* followed by *T. microcarpus* (0.08 mg), whereas minimum quantity (0.04 mg) of Zn was recorded in *T. radicatus*. Maximum amount of Se (0.12 mg) was recorded in *T. microcarpus* followed by 0.11 mg in *T. heimii* whereas minimum amount (0.05 mg) was recorded in *T. striatus.*

Table 2. Macro and Micro mineral elements in twenty wild species (mg/100 g of the sample)

S. No.	Name of Species	Ca	Cu	Fe	Mg	Mn	Se	Zn
1	*Macrolepiotadolichaula*	5 ± 0.72	5 ± 0.92	241 ± 1.73	143 ± 1.00	1± 0.23	0.10 ± 0.05	0.08 ± 0.01
2	*M. procera*	14 ± 0.6	9 ± 0.32	276 ± 0.87	254 ± 2.00	5 ± 0.30	0.08 ± 0.03	0.06 ± 0.03
3	*M. rhacodes*	28 ± 1.40	217 ± 0.50	248 ± 1.74	217 ± 0.50	3 ± 0.53	0.06 ± 0.03	0.09 ± 0.02
4	*Termitomycesbadius*	24 ± 1.42	7 ± 1.48	144 ± 0.90	205 ± 1.05	3 ± 0.32	0.08 ± 0.02	0.06 ± 0.02
5	*T. heimii*	28 ± 1.35	6 ± 0.09	388 ± 0.74	287 ± 0.50	5 ± 0.27	0.1 ± 0.02	0.07 ± 0.01
6	*T. mammiformis*	30 ± 1.00	4 ± 0.46	673 ± 1.00	277 ± 0.50	2 ± 0.53	0.07 ± 0.01	0.06 ± 0.01
7	*T. medius*	204 ± 0.50	7 ± 1.84	454 ± 1.00	330 ± 1.00	13 ± 0.79	0.07 ± 0.01	0.06 ± 0.01
8	*T. microcarpous*	24 ± 1.42	6 ± 0.30	86 ± 1.00	6 ± 0.20	3 ± 0.53	0.12 ± 0.02	0.08 ± 0.02
9	*T. radicatus*	109 ± 1.00	9 ± 0.32	482 ± 1.50	272 ± 1.98	10 ± 0.15	0.09 ± 0.01	0.04 ± 0.01
10	*T. striatus*	15 ± 0.22	11 ± 1.08	82 ± 0.82	191 ± 1.00	2 ± 0.28	0.05 ± 0.02	0.07 ± 0.0

Determination of heavy metals: Traces of some heavy metals viz., As, Pb,Ag, Hg, Cd and Cr were found to be present in some of the presently investigated samples (Table 3). Arsenic (As) content was found to be maximum in *T. striatus* (0.0185 mg) followed by *M. rhacodes* (0.0074 mg), *T. mammiformis* (0.0037 mg) and *T.medius* (0.00010 mg) and *T. badius* (0.00002 mg). This heavy metal was not detected in the remaining species of *Macrolepiota* and *Termitomyces*. Other heavy metals including Pb, Ag, Sb and Cr were not detected in any of the evaluated species of *Termitomyces* and *Macrolepiota*. During evaluation the presence of Hg was detected and its concentration ranged from 0.062 - 0.087 mg in the dry samples of *M. dolichaula, M. procera, M. rhacodes* and 0.016-1 mg in all the seven species

Table 3. Qualitative analysis for heavy metals in *Termitomyces* and *Macrolepiota* species

S.No.	Name of Species	As	Pb	Ag	Hg	Sb	Cr	Cd
1	*Macrolepiota dolichaula*	ND*	ND	ND	0.062	ND	ND	0.0019
2	*M. procera*	ND	ND	ND	0.087	ND	ND	0.0019
3	*M. rhacodes*	0.0074	ND	ND	0.069	ND	ND	0.0014
4	*Termitomyces badius*	0.00002	ND	ND	0.096	ND	ND	0.0045
5	*T. heimii*	ND	ND	ND	0.018	ND	ND	0.0040
6	*T. mammiformis*	0.0037	ND	ND	0.043	ND	ND	0.0027
7	*T. medius*	0.00010	ND	ND	0.10	ND	ND	0.0039
8	*T. microcarpous*	ND	ND	ND	0.094	ND	ND	0.00488
9	*T. radicatus*	ND	ND	ND	0.016	ND	ND	0.0022
10	*T. striatus*	0.0185	ND	ND	0.099	ND	ND	0.0017

of *Termitomyces* evaluated. Cadmium (Cd) was another heavy metal which ranged from 0.0014 – 0.0019 mg in all the 3 species of *Macrolepiota* and 0.0017 – 0.00488 mg in the 7 species of *Termitomyces* evaluated.

Vitamins: Amongst the evaluated taxa (Table 4) *T. reticulatus* (1.45 mg) shows maximum amount of Ascorbic Acid followed by *T. radicatus* (0.96 mg) and minimum in *L. humei* (0.18 mg/100 g). As for other vitamins are concerned, *M. rhacodes* (0.80 mg) possessed highest amount of Thiamine, *T. heimii* (0.12 mg, 0.25 mg) contained maximum content of retinol and riboflavin, respectively.

Table 4. Vitamins in lepiotoid and termitophilous mushrooms (mg/100 g of the sample)

S.No.	Name of Species	Vitamin A (Retinol)	Vitamin B1 (Thiamine)	Vitamin B2 (Riboflavin)	Vitamin C (AscorbicAcid)
1	*M. dolichaula*	0.07 ± 0.01	0.75 ± 0.05	0.13 ± 0.02	0.48 ± 0.02
2	*M. rhacodes*	0.09 ± 0.00	0.80 ± 0.04	0.13 ± 0.03	0.36 ± 0.01
3	*T. heimii*	0.12 ± 0.01	0.21 ± 0.01	0.25 ± 0.01	0.24 ± 0.01
4	*T. mammiformis*	0.11 ± 0.01	0.28 ± 0.01	0.21 ± 0.01	0.30 ± 0.0
5	*T. radicatus*	0.10 ± 0.02	0.42 ± 0.04	0.20 ± 0.01	0.96 ± 0.03
6	*T. reticulatus*	0.01 ± 0.00	0.26 ± 0.02	0.23 ± 0.01	1.45 ± 0.10
7	*Lepiota humei*	0.16±0.01	0.49±0.01	0.20±0.03	0.18±0.01

Nutraceutical Studies

Evaluation for the presence of phenolics, flavonoids, carotenoids and alkaloids in the wild edible lepiotoid and termitophilous mushrooms was done by employing standard biochemical techniques (Table 5).

Table 5. Phenolic compounds in wild *Termitomyces* and *Macrolepiota* species (On dry weight basis)

Sr. No.	Species	Phenolic compounds (mg/g)	Flavonoids (mg/g)	β-carotene (µg/g)	Lycopene (µg/g)	Alkaloids (mg/g)
1	*T. microcarpus*	25.85±0.10	2.02±0.17	0.28±0.01	0.14±0.02	0.056±0.03
2	*T. badius*	15.00±0.50	1.49±0.08	0.50±0.03	0.19±0.01	0.052±0.03
3	*T. medius*	16.41±0.01	1.51±0.01	0.17±0.00	0.04±0.00	0.053±0.09
4	*T. striatus*	15.04±0.02	1.38±0.02	0.39±0.01	0.27±0.02	0.050±0.16
5	*T. heimii*	21.32±0.33	1.72±0.02	0.11±0.02	0.03±0.02	0.046±0.04
6	*T. mammiformis*	22.49±0.50	1.86±0.15	0.27±0.02	0.06±0.01	0.077±0.05
7	*T. radicatus*	20.14±0.05	1.67±0.18	0.29±0.00	0.09±0.01	0.046±0.08
8	*M. dolichaula*	5.90±0.58	1.76±0.20	0.12±0.02	0.05±0.01	0.103±0.01
9	*M. procera*	11.0±0.87	1.46±0.04	0.29±0.07	0.07±0.00	0.048±0.03
10	*M. rhacodes*	16.81±0.05	1.36±0.03	0.26±0.01	0.12±0.02	0.053±0.02

Evaluation for Phenolic compounds: Total phenolic content of the edible termitophilous and lepiotoid mushrooms was determined colorimetrically using Folin - phenol method. Maximum amount of phenolic content was documented in *T. microcarpus* (25.85 mg/g) followed by *T. mammiformis* (22.49 mg/g) and minimum amount of phenolic content was evaluated in *M. dolichaula* (5.9 mg/g). Out of the examined species, all species of *Termitomyces* contained substantial amount of phenolics.

Flavonoids: Flavonoids are also polyphenolic compounds that are ubiquitous in nature. The quantity of flavonoids ranged from 1.36 mg/g in *M. rhacodes* to 2.02 mg/g in *T. microcarpus*.

Carotenoids: The β-carotene content was found in very low amount in different species ranging from 0.11 μg/g in *T. heimii*to 0.50 μg/g in *T. badius*. Lycopene content ranged from 0.03 μg/g in *T. heimii* to 0.27 μg/g in *T. striatus*.

Alkaloids: *M. dolichaula* contained 0.103 mg/g of alkaloids which was maximum in comparison to all other evaluated species of *Macrolepiota* and *Termitomyces*.

DISCUSSION

The nutritional analysis carried out on these mushroom samples showed that they are all rich in proteins, fibers, moisture and carbohydrate contents, in contrast to low fat levels, which make them suitable to incorporate into low caloric diets. These results are in agreement with different studies conducted by various workers [25, 27, 28]. In case of *Termitomyces* species evaluated by Mukiibi [29] and Zakia *et al.* [30] the carbohydrate content has been reported to range from 54.2% - 62%. Various medicinal uses were report-ed by Nakalembe *et al.* [31] in many species of termi-tophilous mushrooms (*T. microcarpus*, *T. auranti-cus*, *T. eurrhizus*, *T. clypeatus*, and *T. tyleranus*). Oboh and Shodehinde [32] found a higher protein content in *T. mammiformis* in comparison to other edible mushrooms of Nigeria, and more protein content was found in the pileus than the stipe (28.6% and 24.8%, respectively). Masamba and Kazombo-Mwale [33] evaluated 3.9% protein while working with *T. letestui*. Nabubuya *et al.* [34] studied the nutritional properties of *T. microcarpus* and evaluated 25.48% protein content. Mukiibi [29] and Zakia *et al.* [30] documented high percentage (6.8% - 15.6%) of dry ash in different species of *Termitomyces* including *T. microcarpous* (14.1%). Crisan and Sands [16] documented an average mushroom to contain approximately 90% moisture when fresh and 10% - 12% when air-dried.

Alkaloids were also found in very small concentrations ranging from 0.046-0.077 mg/g which is higher than reported earlier in *Schizophyllum* commune (0.015%) and *Polyporus* spp. (0.013%) [37].

Total phenolics evaluated in species were significantly higher than several mushroom species such as *Lycoperdon perlatum*, *Clavaria vermicularis, Marasmius oreades*, *Russula delica*, *Morchella conica*, *Pleurotus pulmonarius, Ganoderma lucidum* and *Coriolus versicolour* has been documented by a number of workers [35-39]. Present findings are in line with those of Barros *et al*. [25], Ramesh *et al.* [36] on their research on bioactive compounds.

Olfeti *et al*. [41] documented the presence of P (8.8 mg), K (23.9 mg), Na (1.1 mg), Ca (1.4 mg) and Mg (1.8 mg) in *M. procera* which is low from present study.

There are several reports about the accumulation of high concentrations of heavy metals in mushrooms [42-45]. Elekes *et al.* [44] recorded the bio-accumulation of some heavy metals in the fruit-ing body of wild growing mushrooms. Slávik *et al*. [46] observed the highest amount of total mercury content is 176.40982 mg/kg dry matter in two fruit bodies of *M. procera* which is much more than our present investigation. Falandysz [47] determined Selenium in fruit body of *Macrolepiota* spp., with an average range of 5 to < 10 μg/g dw and *M. rhacodes* with < 10 μg/g dw which is less then present findings. All species of *Macrolepiota* and *Termitomyces* were evaluated to possess some traces of heavy metals, though within the permissible limits of human consumption [48]. The results obtained in case of vitamins are in agreement with the similar nature of work from elsewhere [25, 27, 28, 49, 50].

In view of their composition, these mushrooms needs to be used directly in diet so as to promote health, taking advantage of the additive and synergistic effects of all the bioactive compounds present in them. Therefore, wild edible mushrooms such as species of *Termitomyces* and *Macrolepiota* a need to be domesticated for their large scale production and subsequent use as natural nutrition sources.

Figure 1. *Termitomyces microcarpus*

Figure 2. *Termitomyces mammiformis*

Figure 3. *Termitomyces radicatus*

Figure 4. *Termitomyces medius*

Figure 5. *Termitomyces heimii*

Figure 6. *Termitomyces striatus*

Figure 7. *Termitomyces badius*

Figure 8. *Termitomyces reticulatus*

Figure 9. *Macrolepiota rhacodes*

Figure 10. *Macrolepiota procera*

Figure 11. *Macrolepiota dolichaula*

Figure 12. *Lepiota humei*

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